

# Efforts to Mitigate Climate Change Repercussions on Oyster Populations and Natural Oyster Recruitment via Aquaculture Practices in Delaware



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# Acknowledgement

- USDA Evans-Allen, NSF-EPSCOR & DSU-School of Excellence, DuPont Co. Clear into the Future Program
- The Center for the Inland Bays
- UD Sea Grant
- Sussex County Council
- Oyster Gardeners
- Undergraduate Interns
- Graduate Students
- Technicians



# The Eastern Oyster (*Crassostrea virginica*)

- Oysters are a keystone species
  - Clean the water & remove excess nutrients, suspended particles & bacteria
  - Reefs offer unique habitat



- Stabilize shorelines
- Habitat forming species
- Bioaccumulation (indicator species)
- Supporting the diversity of ecologically & economically important species

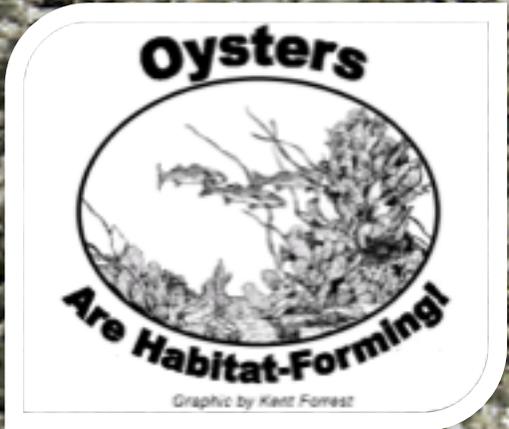


- Fish
- Invertebrates
- SAV



- We are working to conserve an ecosystem & culture
  - Shellfish harvest
  - Tourism
  - Recreational
  - Commercial fishing





# Coastal Erosion Control

TEXAS NEWS

NEWS FROM AROUND THE STATE OF TEXAS

## More Oyster Reefs Could Help Fight Erosion On Texas Coast

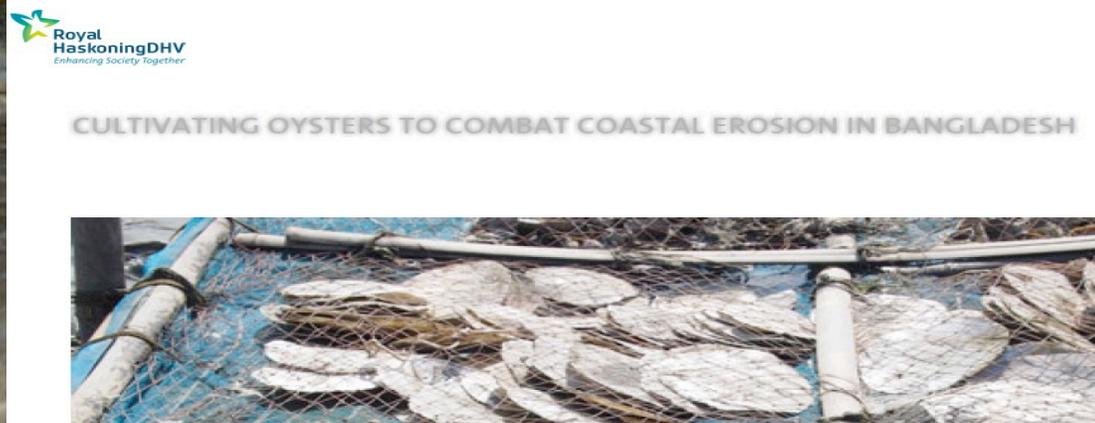
Texas could start approving and funding plans to build reefs closer to the shoreline, which scientists argue would help combat coastal erosion

By Marissa Barnett

Published at 2:57 PM CST on Jan 22, 2018



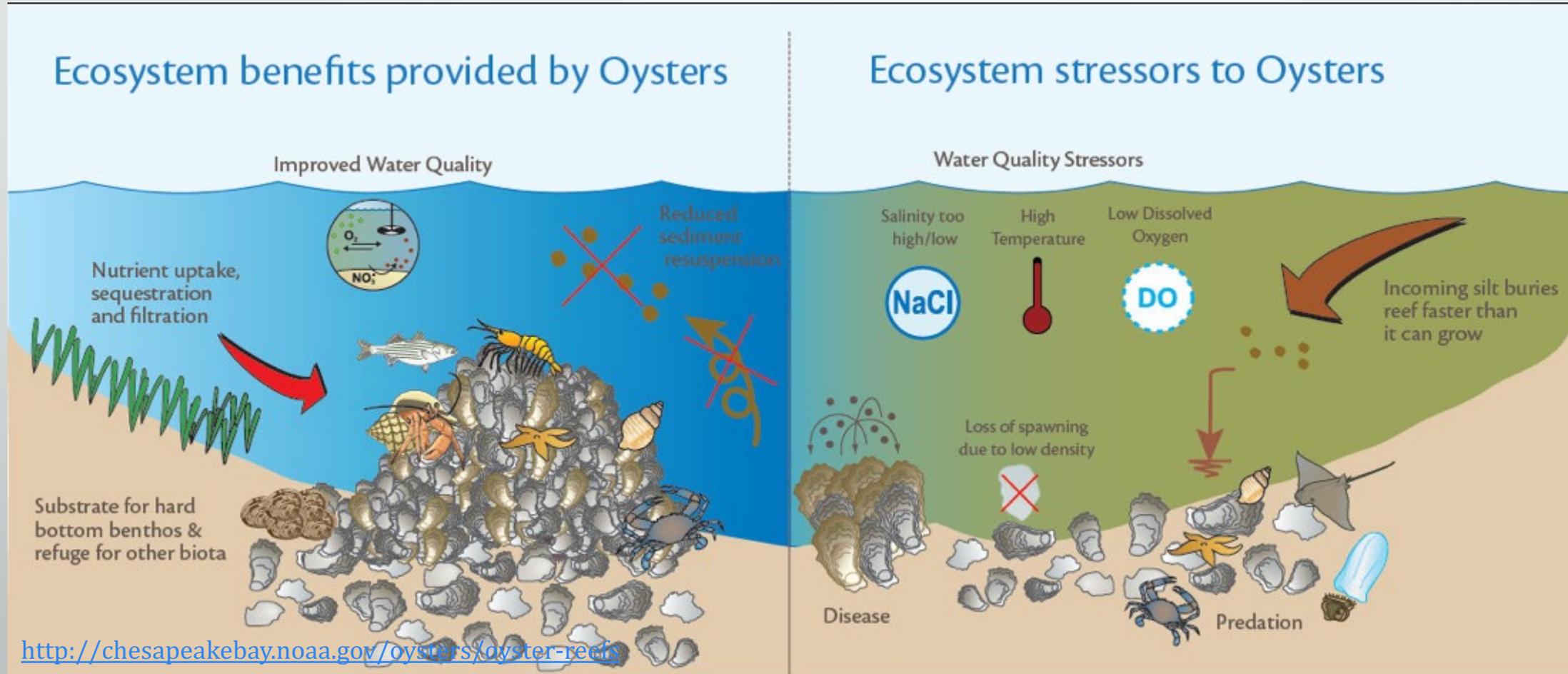
<https://myouterbankshome.com/>



<http://www.wlf.louisiana.gov/news/33515>

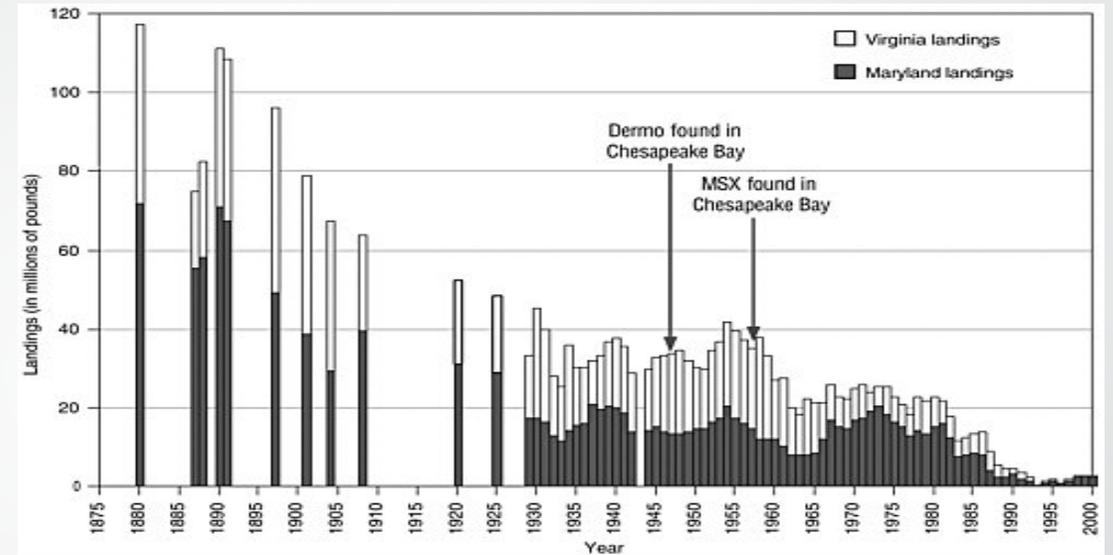
rd.com

# Ecosystem Benefits



# The State of Oysters in Delaware

- Oyster populations have declined by over 95% due to:
  - Overharvesting
  - Diseases (parasitic)
  - Dredging
  - Decades of land-uses & developments resulted in:
    - Sustained eutrophication
    - Sediment erosion



<https://www.nap.edu/read/10796/chapter/3>

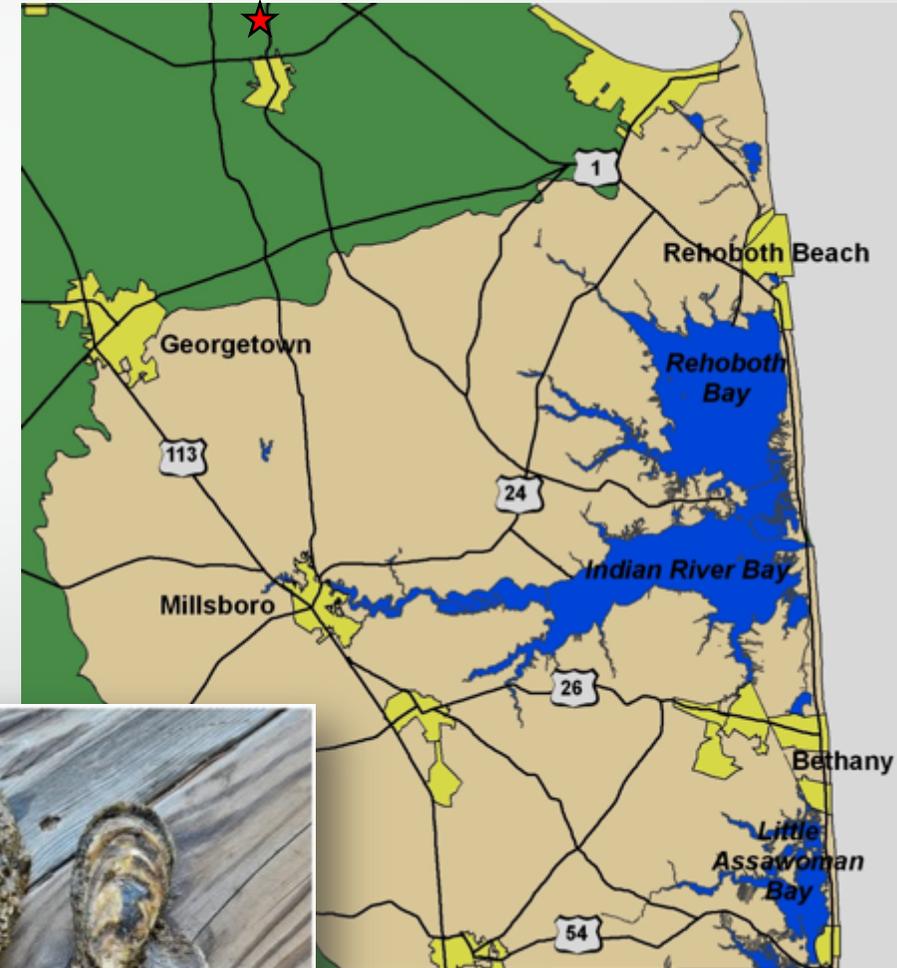


**Decreased oyster populations**

**Degraded water quality**

# Delaware Inland Bays (DIB)

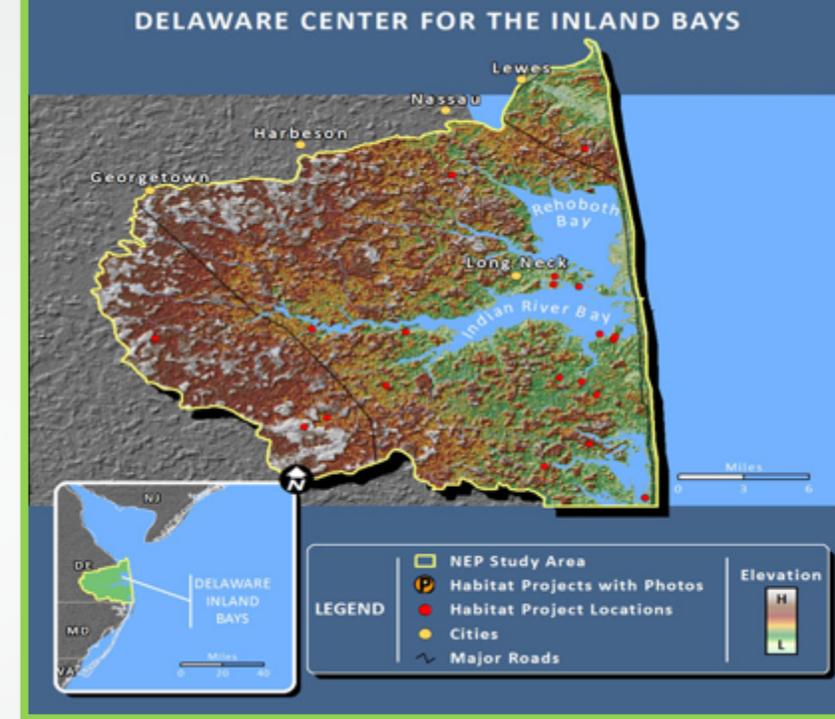
- Comprised of 3 water bodies
  - Rehoboth Bay
  - Indian River Bay
  - Little Assawoman Bay
- 78 km<sup>2</sup>
- Shallow: 1m–2.5m
- Low flushing rates
- Few marine inlets



COURTNAY JANIAK

# Delaware Inland Bays

- Increase residential development
- High coastal tourism (Dorfman & Rosselt 2008)
- Agriculture practices
  - Corn, soybean & poultry production
  - Primary N & P contributors (Mackenzie et al. 1999)



	Indian River Bay		Rehoboth Bay		Little Assawoman Bay	
Nutrient Sources	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus
Agriculture	44.6%	39.4%	33.0%	17.0%	54.7%	52.6%
Boating	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%
Forest	11.0%	19.2%	7.4%	9.4%	6.7%	19.5%
Point Sources	12.5%	15.0%	27.3%	56.9%	0.0%	0.0%
Rainfall	6.2%	8.6%	8.8%	6.9%	12.8%	11.5%
Septic Tanks	16.0%	9.3%	11.2%	3.8%	14.6%	5.6%
Urban	9.8%	8.6%	11.7%	5.9%	11.2%	10.8%

[www.inlandbays.org/cib\\_pm/photos2005/wsmap2.jpg](http://www.inlandbays.org/cib_pm/photos2005/wsmap2.jpg)

**Relative contributions of nitrogen & phosphorus sources in the Inland Bays (CIB 1993).**

# Condition of Inland Bays

- Nutrient enriched (eutrophic)
- Sediment erosion, high turbidity
- Periodically hypoxic → fish kills
- Being developed rapidly
- Near extirpation of oyster population
- Reduced diversity and abundance of fishes, inverts & SAV



# Oyster Gardening

- Delaware State University joined the program in 2005:
  - Oyster growth and survivorship
  - Community structure and habitat value
  - Water quality and nutrient cycling/utilization



● Oyster Gardening Sites



Center for the Inland Bays



- This involvement has facilitated the expansion of the program
- Over 200 community volunteers in just 5 years!

# Program Goal

- The primary program goal is to engage community in oyster restoration efforts
- To develop & evaluate the success of the oyster gardening program in Delaware by monitoring:
  - **Remote set & spat survey**
  - **Gear types**
  - **Oyster growth & survival**
  - Local water quality
  - Habitat value of oyster aquaculture gears
  - HABs & bacterial monitoring
  - Nutrient source tracking
  - Oyster population assessment via genetic research





# How We Have Done?

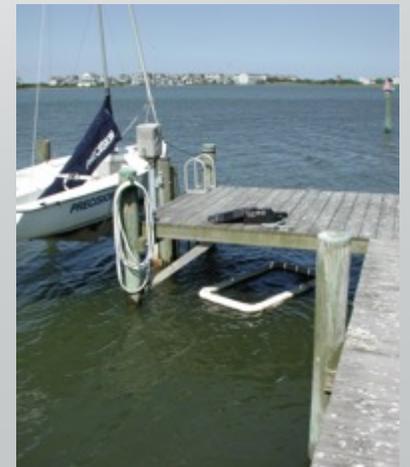
- To supply gardeners spats, disease-resistant oyster larvae was obtained from Rutgers University's Haskin Shellfish Laboratory



- A remote setting process was then used to allow the larvae to settle on cultch bags



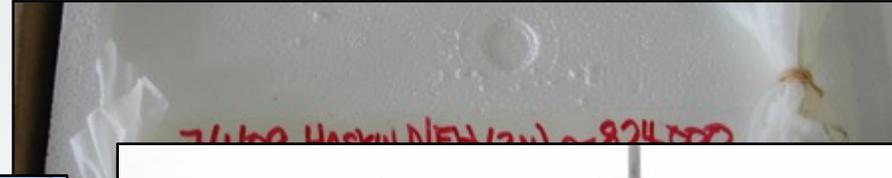
- The 5-10mm spat on shell was transferred to Taylor floats that were deployed at volunteers' docks throughout the Inland Bays



# Settlement in Remote Set



# Settlement in Remote Set



# Settlement in Remote Set

The number of live and dead spat are counted on each individual shell.

Spat were counted as dead *if*:

- Right valves were loose to the touch
- Both valves were still articulated, but oyster was empty
- Oyster body was attached but right valve was missing or crushed

2009: Bags Only

2013: Trays Only

2011: Bags + Baskets

2015: Baskets + Trays



# Result Summary



- The estimated settlement rates (<13%) are less than ideal for all sets prior to 2015's tray experiment. This setup yielded >2% settlement, making this the best option for spat recruitment.
- Overall survival of settled larvae was 85%, 93%, 95%, and 91% in 2009, 2011, 2013, and 2015, respectively regardless of setup.
- Mean temperature was 25°C in 2009, 24.5°C in 2011, 23°C in 2013, and 24.8°C in 2015, and was found to be significantly different.
- Salinity and D.O. showed no difference between years.

# Discussion

## Benefits of Aquaculture Trays:

- 1) distribute shell most uniformly within the tank
- 2) require less handling time than mesh bags
- 3) more environmentally friendly (used multiple sets/years)
- 4) 2015 setup better to reduce mud buildup
- 5) the trays make washing sediments off of the shells is easier
- 6) gave our program the highest efficiency yield**

## Benefits of Regular Baskets:

- 1) hold a high volume of shell

## Benefits of Mesh Bags:

- 1) inexpensive
- 2) volunteers can theoretically pick up bags and bring them home themselves to set into their gardens



# Taylor Floats



- 2 baskets per Taylor float
- ~ 150-350 oysters/float
- Grown in floats for 2 years
- Gardening efforts are strictly for education and restoration

# Why It Works?

- In the floating cage system, community members throughout Southern Delaware are:
  - Keeping the oysters clean & protected
  - Being given the unique opportunity to observe first hand many of the important ecological services provided by oysters



- Workshops & training sessions are held for gardeners interested in learning:



- How to construct the Taylor floats
- The best methods for monitoring, cleaning, and caring for their oysters
- Monitoring environmental parameters

# Grow oysters. Then what?

- **Problem:** What do we do with these oysters after they have been grown in the oyster gardening program for 2 years?
  - Not for sale or for consumption
- Creation of James Farm Ecological Preserve (0.25 hectare oyster reef)
  - Poor survival results on 2 dimensional trays
    - Sedimentation
  - Idea to utilize ripraps



# What's in Store?

- The larger, healthier oysters resulting from the gardening program will contribute spat to enhance the struggling wild populations
  - Artificial reef creation
  - Rip-rap planting
- Participation by private land owners is critical for aiding in the creation of new reefs
  - Placing oysters in areas of rip-rap



# Why We Restore Oysters?

- Increased interest and participation of community members shows the strong desire to restore oyster populations and improve local water quality in Southern Delaware!
- **It will only continue to grow with further education and outreach programs!**



- The volunteer community members hope that by reestablishing the oyster populations in the bays, Delaware's waterways can return to a healthy state and sufficiently support the diversity of organisms that once abounded



*"...I'd like to see if the entire community is interested in cleaning up by having some oysters live in their canal..."*

*— Prospective oyster gardener*



- Oyster gardening is a simple and enjoyable step towards bringing communities together to achieve these goals

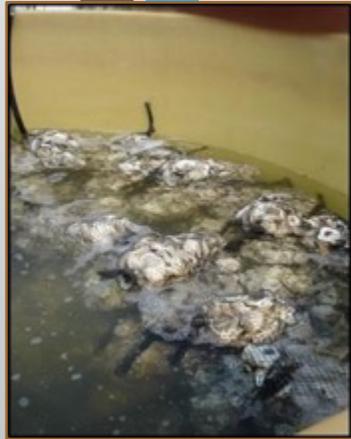
# Oyster Aquaculture



Man-made oyster reef



Healthy oysters grown in the Inland Bays



Oyster bags for remote set

- The culture of the Eastern oyster in aquaculture gear has become a viable component of restoration programs in many states on the East Coast of the United States
- These operations may provide many of the similar ecological services as natural or restored reefs



Marengi and Rossi-Snook sampling an oyster float



Oyster trays for remote set



Constructing an artificial reef structure



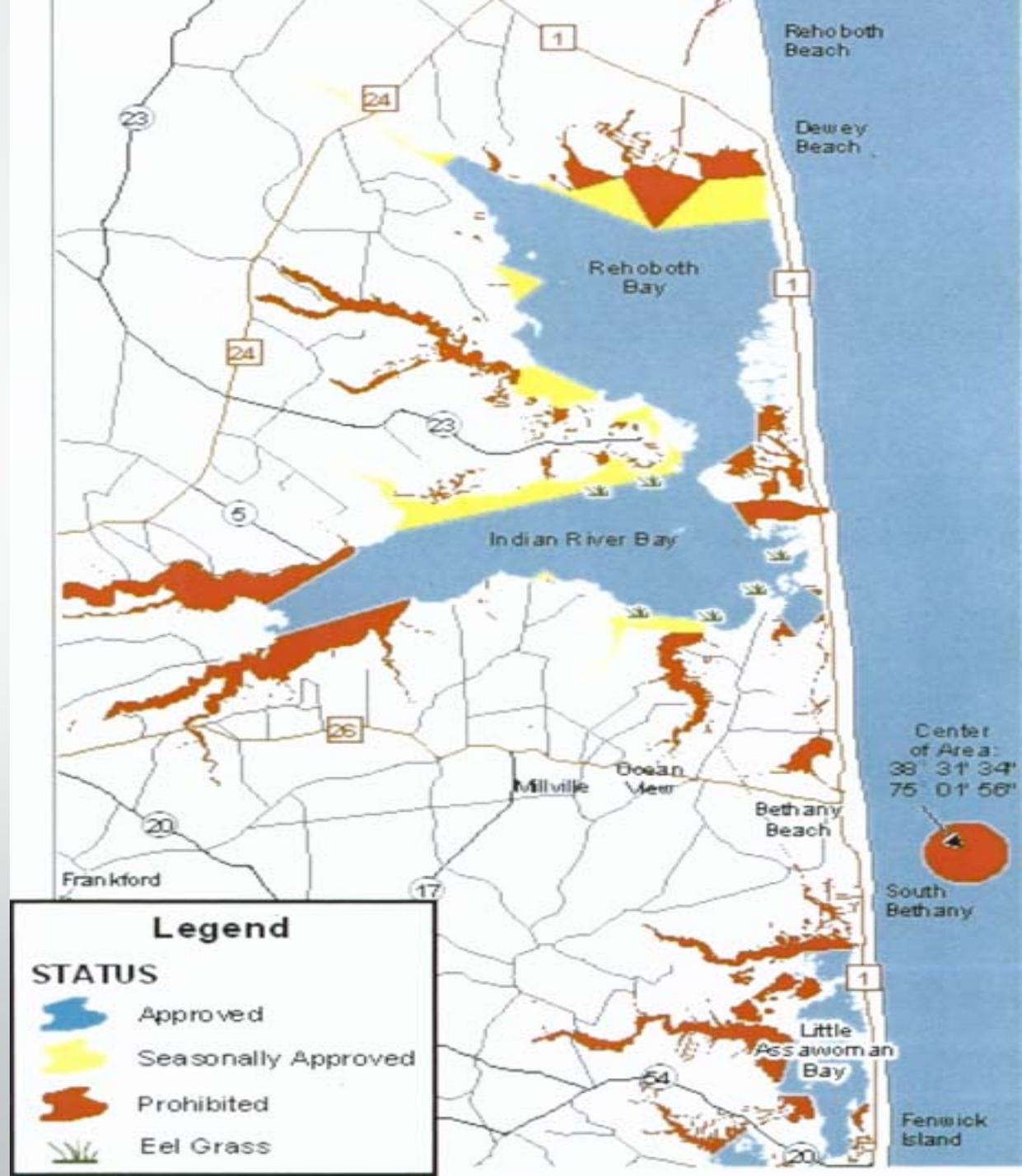
Bottom culture gear



Planting oyster spat in rip-rap

# Delaware Inland Bays Shellfish Growing Waters

- DE approved commercial aquaculture in August 2013
  - About 50 km<sup>2</sup> approved for shellfish culture ground ([www.dnrec.delaware.gov](http://www.dnrec.delaware.gov))



# Program Goal: *Bottom, Hanging, and Floating Gear for Growing Eastern Oysters*

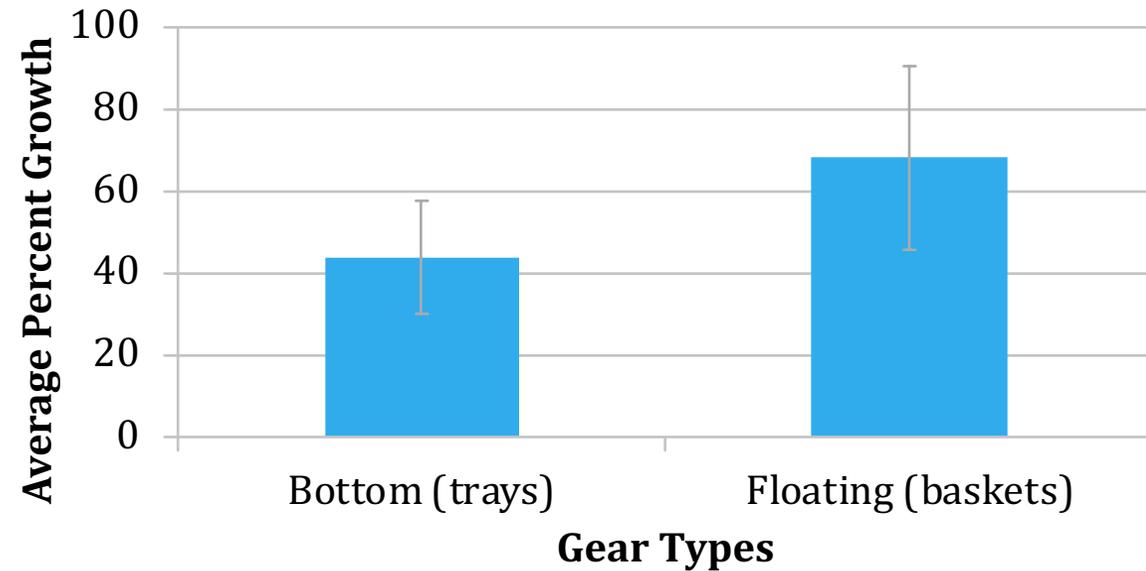
- In May 2017, DNREC's Division of Fish & Wildlife announced its first shellfish aquaculture leasing lottery for the Delaware Inland Bays
- To compare the growth of hatchery-raised oysters housed in various oyster culture gears to determine which gear better was suited for commercial aquaculture practices in Delaware
- To identify what aquaculture gear performs better in the growth and survival of the Eastern oyster



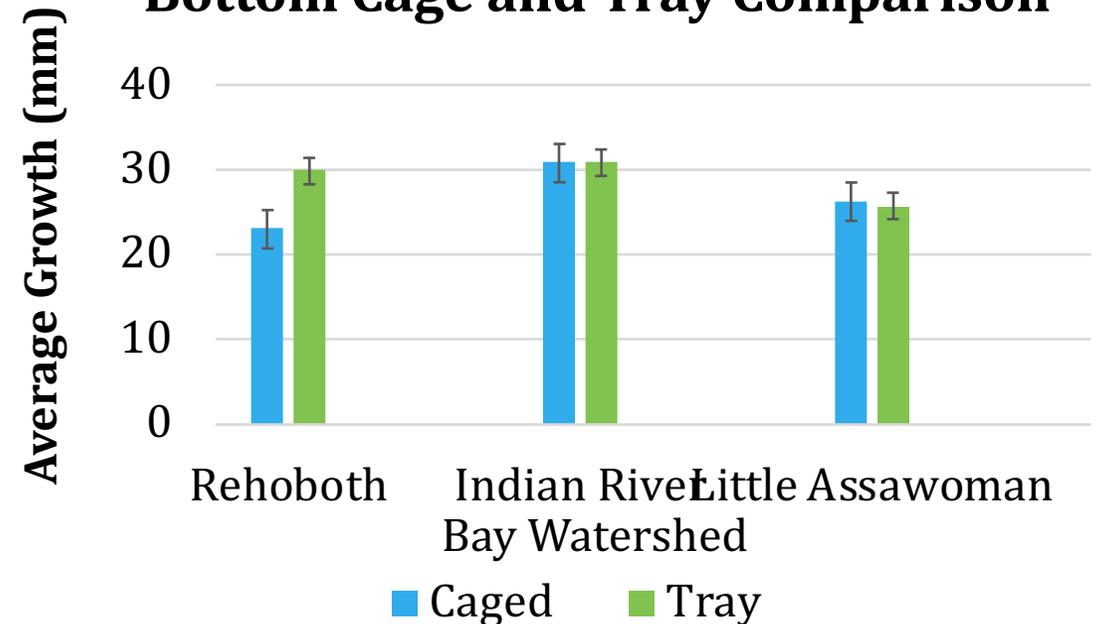
# Result Summary

- Oysters in the floating gear showed an average of 24.2% greater growth than those in the bottom gears
- No difference in oyster growth or survival between bottom trays or cages
- Four years study favors floating gear use for aquaculture in DIB

### Bottom Cage and Float Comparison



### Bottom Cage and Tray Comparison

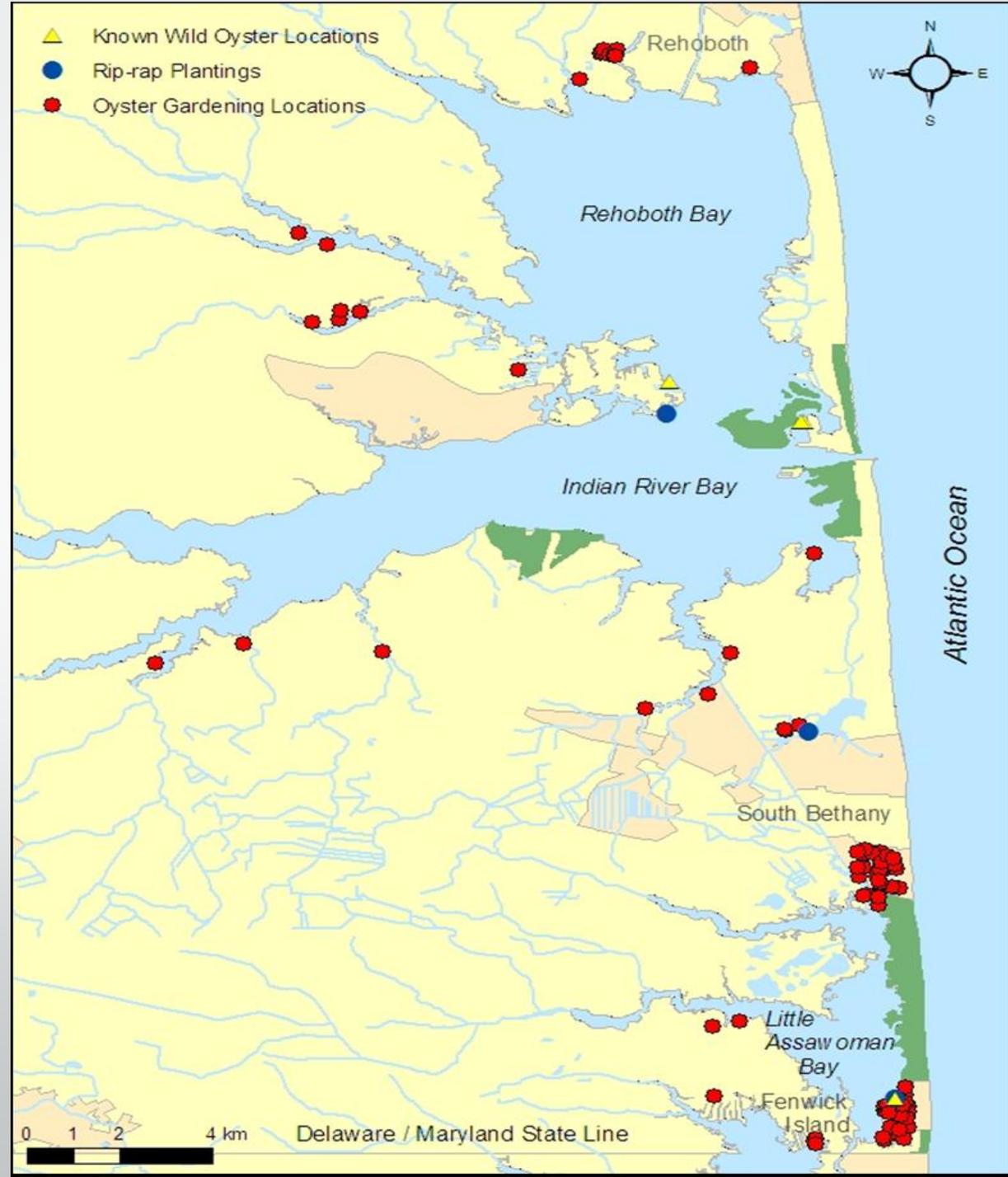


# Discussion

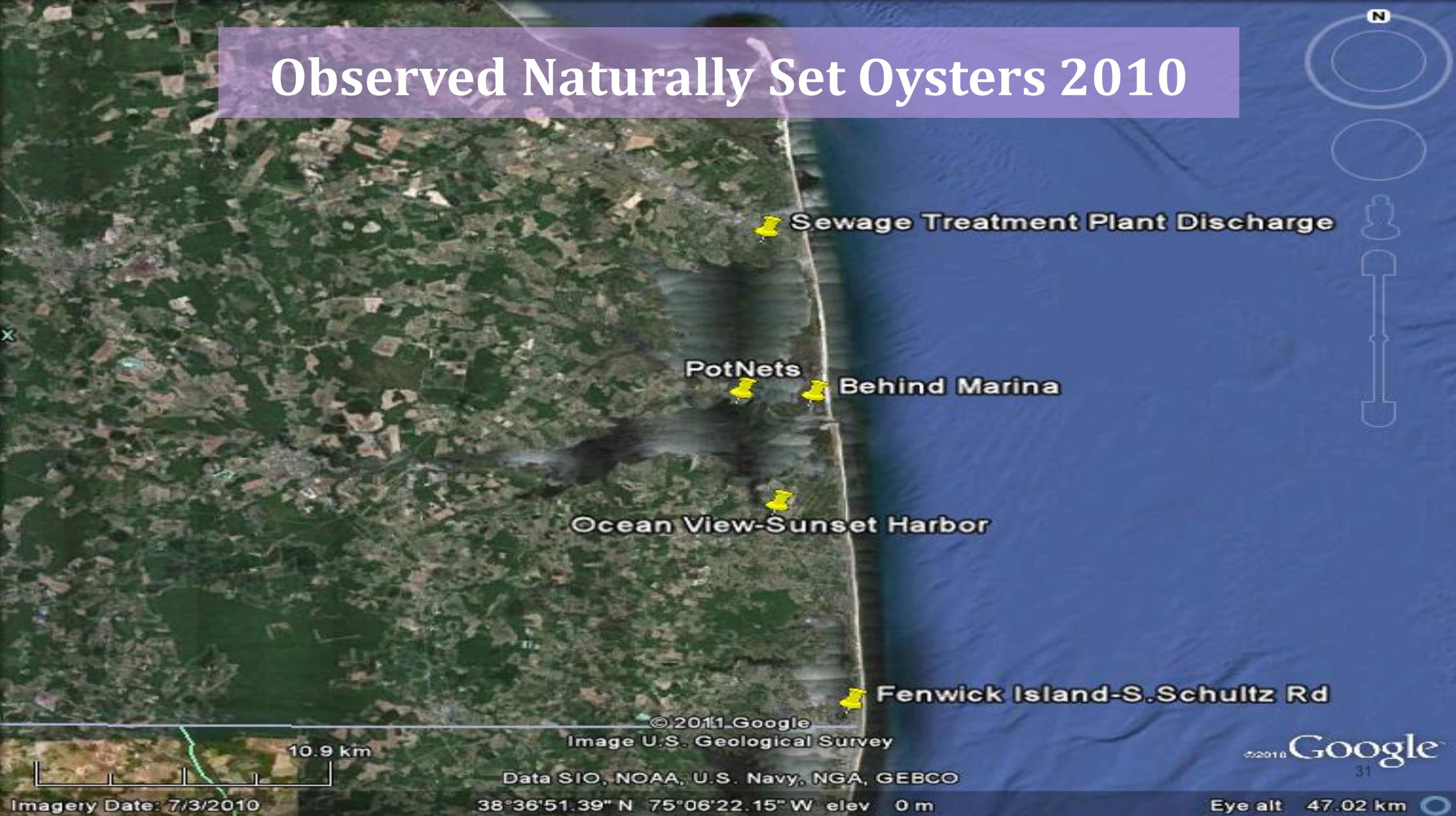
- Both of bottom trays and hanging baskets were more labor intensive than the use of the baskets in the Taylor float
- Bottom cage performance is tide dependent
- Use of hanging baskets required continual watch to ensure that the rope suspending the baskets in the water didn't become wound around the pier pilings causing oysters off water at high tide
- Cage gear was heavy and required two individuals to install, whereas the tray could be installed by a single individual
- Tray gear required more time to assemble; PVC pipes and pins required to keep trays in place
- Both cage and tray gear required scrubbing around the equipment mid-study to clear away overgrowth of algae

# Oysters in Delaware Inland Bays

Map of Delaware's Inland Bays showing oyster gardening locations, riprap planting locations, and known wild oyster locations (Marenghi 2009).



# Observed Naturally Set Oysters 2010



Sewage Treatment Plant Discharge

PotNets

Behind Marina

Ocean View-Sunset Harbor

Fenwick Island-S.Schultz Rd

10.9 km

Imagery Date: 7/3/2010

© 2011 Google  
Image U.S. Geological Survey

Data SIO, NOAA, U.S. Navy, NGA, GEBCO

38°36'51.39" N 75°06'22.15" W elev 0 m

© 2010 Google

Eye alt 47.02 km



# Why Aquaculture Can Make A Difference?

- One oyster filter approximately 50 gallons of water per day.
- Oysters currently in the project are filtering 1.8 million gallons of water daily in DIB
- DIB has a surface area of 32 square miles, with an average depth of 4 feet
- This makes for a total volume of 26.7 billion gallons
- It would take at least 533.83 million more oysters to filter DIB daily
- There are currently about 40,000 oysters

**The Restoration Project is a great step forward but large-scale oyster aquaculture will be needed to generate a much larger impact!**



# Questions?

**More research on impacts  
of oyster structures and  
aquaculture gear on  
erosion and wave  
dissipation**

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